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PROCESS FOR THE MANUFACTURING OF CELLULOSE PULP

The present invention concerns a method and a system for the production of cellulose pulp in which wood raw material that principally consists of softwood, preferably in the form of cut wood chips, is treated in several stages in various treatment steps, whereby one of the steps comprises the cooking of the material in an alkali cooking fluid, with the goal of obtaining improved quality with respect to tensile strength and increased yield.

THE PRIOR ART

The yield calculated with respect to wood raw material is very significant when cooking, and it normally lies around 45% for softwood and approximately 50% for hardwood. An increase of a single percentage point results in a production plant of normal size, 1,500 tonnes of pulp per day (approximately 3,000 tonnes of wood raw material per day), giving an increased production of 30 tonnes. With a pulp price of approximately USD 700 per ADT, this gives an increase in revenue of at least USD 21,000 per day. An increase in marginal production gives essentially a net profit. Furthermore, the load on the recycling plant is decreased, if a lower fraction of cellulose is sent to evaporation and combustion in the soda furnace, something that in turn could enable a capacity increase. The soda furnace is often the limiting production resource (bottleneck), which means that an increase in total capacity of an order of magnitude of 2% could be obtain, and according to the example given above, thus enabling a total increase of capacity of 60 tonnes per day.

Thus it can be realised that attempts have been made for a long time to increase the yield, without relinquishing requirements on quality or other factors that affect the cost. Many different methods with this aim are thus known.

One known method for increasing yield, for example, has been the addition of polysulphide during the cooking, such as known through, for example, WO 95/32331. However, a problem associated with this method is that polysulphide is subject to

thermal decomposition, which leads to a major part being broken down by the high cooking temperature before the effect of increasing the yield of pulp is obtained.

Another type of known principle to solve the problem is based on the use of black liquor as impregnation fluid in an impregnation zone before the cooking stage. The document US 5,080,755 reveals a system with black liquor in the feed system. US 5,053,108 reveals a variant in which black liquor withdrawn from the digester is returned to the high-pressure feeder where it is to form a major part of the treatment fluid in the transfer flow to the digester. EP 477,059 reveals a modified variant in which wood chips impregnated with black liquor are raised to cooking temperature before the principal addition of white liquor takes place. These examples are only some of a number of various known methods that demonstrate that many different suggestions for processes have been studied with the aim of improving yield while maintaining pulp quality.

Known methods demonstrate either disadvantages related to cost and/or do not provide sufficient quality with respect to beatability or tensile strength.

AIM AND PURPOSE OF THE INVENTION

One aim of the invention is to increase the yield when producing cellulose pulp, where wood raw material that principally consists of softwood, preferably in the form of cut wood chips, is treated in several stages in various treatment steps, whereby one of the steps comprises the cooking of the material in an alkali cooking fluid, through a controlled addition of wood raw material in the form of hardwood at an amount corresponding to 1-20% of the amount of softwood, preferably 3-15%, more preferably at least 5%. A second aim of the invention is to be able to produce pulp with improved properties with respect to tensile strength and/or beatability.

It has been discovered, somewhat surprisingly, that the invention allows the yield to be increased, often to a significant degree, with essentially maintained, or even improved, properties for the pulp, something that means that significant economic advantages can

be obtained. Most significantly, it has turned out that pulp produced according to the invention demonstrates improved properties with respect to tensile strength and beatability, something that is of major significance for many paper products. It is important that the addition of hardwood takes place in a controlled manner, such that the improved quality can be maintained on an even and high level, from the digester, whereby subsequent bleaching and/or treatment stages can be optimised.

The invention can be applied both on steam phase digesters and hydraulic digesters; with inverted top separators, with top separators that feed downwards and with types that lack a top separator.
The invention can also be applied for batch-cooking, in which the chips are fed into a vessel where treatment subsequently takes place in sequence with the chips held stationary in the vessel.

DESCRIPTION OF DRAWINGS

The invention will now be described in more detail with reference to the attached drawings, where:

Figure 1 shows a diagram comparing tensile strength (as a function of the degree of beating) between pulp from softwood (*Pinus radiata*), produced according to the invention with the inclusion in the mixture of 5% eucalyptus, with a pulp from softwood (*Pinus radiata*) prepared according to a conventional method.
Figure 2 shows one preferred embodiment of a system, shown schematically, according to the invention.
Figure 3 shows a modified design of the system according to Figure 1.
Figure 4 shows a further modification according to the invention.
Figure 5 shows a second diagram with a comparison of tensile strength (as a function of the degree of beating) between a conventional pulp from softwood (*Pinus sylvestris*), produced according to the invention with the inclusion in the mixture of 15% Scandinavian birch, with a pulp produced according to a conventional method, and

Figure 6 shows the increased yield from cooking according to the invention with the pulp from Figure 5.

DETAILED DESCRIPTION

Comparative tests have been carried out with the aim of evaluating the invention. The same cooking conditions have been used in the comparative tests and the same original material with respect to softwood has been used. A conventional method was used in one cooking experiment, whereby the wood raw material was 100% constituted by softwood. Softwood was used for 97% of the raw material in the method according to the invention, while 3% was constituted by pin chips of birch.

Table 1

Comparison between conventional cooking and the invention

Pulp:	SW Conifer	SW+3% pin chips of birch
Cooking run number:	CK 2434	CK 2439
Kappa	23	24
Viscosity, dm^3/kg:	1146	1170
Weighted mean fibre length, mm	2.38	2.34
Zero Span, Nm/g:	145	144
Yield, %:	45.7	46.3 (47.8)
Interpolated properties at tensile strength 80 kNm/kg:		
Revolutions, PFI	350	100
Slowness, °SR:	15.0	15.0
Density, kg/m^3:	655	655
Air resistance, sec./100 ml:	5.2	5.6
Burst index, MN/kg:	5.7	5.4
Tear index, Nm^2/kg:	17.1	16.0
Tensile stiffness index, MNm/kg:	6.5	6.3

As the comparative experiments make clear, a significantly improved yield was obtained according to the invention, 2 percentage points when calculated only with respect to the softwood, and as much as 0.6% when calculated relative to the total amount of wood, including the birch chips. Furthermore, it is shown that a considerably improved tensile strength (80/100) is obtained with a pulp according to the invention.

Figure 1 shows the tensile strength (along the y-axis) as a function of the degree of beating (along the x-axis), comparing a pulp produced according to the invention (the upper curve with 5% hardwood in the form of eucalyptus) with a pulp produced according to a conventional method (lower curve), i.e. using solely softwood. The same cooking conditions and cooking process (CoC™, Compact Cooking, which has been developed by Kvaerner Pulping AB) have been used in all experiments. It is clear that the pulp produced according to the invention demonstrates a tensile strength that is improved by 10-20%, which is of major significance for the production of certain paper products.

A probable explanation of the considerable improvement in tensile strength is that an increase in yield principally due to xylan is obtained with a method according to the invention. Xylan is a type of hemicellulose, and it can give improved beatability, which in turn means an improvement in strength. To put it another way: a pulp is obtained according to the invention that is easier to beat, which means that the desired tensile strength can be achieved at a lower degree of beating (fewer revolutions) than that obtained with a pulp produced by conventional methods.

Figure 2 shows schematically a preferred plant according to the invention. A unit 1 for the preparation of raw material is shown, containing a chip mill. Raw materials in the form of both softwood logs 2 and in the form of hardwood logs 3 are supplied to the raw materials preparation unit 1. A control unit 6 is arranged to control the flow of hardwood logs 3 and that of softwood logs 2. The control unit 6 can use any form of prior art technology to control the amounts that are supplied to the chip mill in the raw materials preparation unit 1 in the manner desired. It can, for example, be the weight

that is used, or it can be physical sensors and/or optical sensors, etc. If physical or optical sensors are used, the control unit 6 ensures that the desired quantities of logs of each type of wood raw material are supplied to the chip mill. If a mixing ratio of approximately 3% is desired, the control unit 6 in this case ensures that, for an input flow of 100 logs, softwood constitutes 97 of the logs and hardwood 3 of the logs, on the condition that the logs are approximately the same size. The control unit 6 in its simplest form can take the form of a supply that is manually monitored, by using, for example, a conventionally used manually controlled grapple loader that can take, when fully loaded, for example 80 logs of normal size. In order to obtain a continuous mixture at a level of 5%, thus, the supply can be controlled with the aid of the manually controlled loading machine in such a manner that four logs of hardwood are added after and between each full load of softwood. Another simple alternative solution, according to the same principle, is that the grapple loader is allowed to load a maximum of 20 logs (for example, by adaptation of the gripper), and that one log of hardwood is loaded between each full load of softwood, whereby a mixture containing approximately 5% hardwood is obtained. The chips are fed after the chip mill, which provides a mixture of softwood chips and hardwood chips according to what is desired, to storage, appropriately via a transporter 4, which in the case shown leads to a chip bin 10.

The invention will be described below in association with the use of a specially preferred form of continuous cooking. Chips are fed in this case down into the chip bin 10 where the chips are warmed in a known manner using steam, St, with the extraction of weak gases, Gas. The chips warmed in this manner are subsequently led to a chip chute 11 where the chips are mixed to a slurry to give a suitable fluid/wood ratio, appropriately through the addition of white liquor, WL, possibly in combination with the addition of a certain amount of black liquor (not shown in the drawing). The chips are fed onwards through a sluice feeder at the bottom of the chip chute 11 using a high-pressure feeder 12 through a transfer flow 13a, 13b to a pressurised treatment vessel 15 for black liquor impregnation. The fluid that is added to the chip chute 11 and that accompanies the chips along the flow 13a is separated from the chips to a large

extent with a top separator 14, and is returned to the high-pressure tap 12 via the return flow 13b.

The addition of white liquor in the chip chute 11 ensures that a relatively short retention time is obtained at an intermediate temperature, in the region of 50-140°C for approximately 2-60 minutes, preferably 2-10 minutes, and this is the reason that a high alkali level, if present, does not have time to influence the strength of the pulp.

An impregnation with black liquor takes place in the treatment vessel 15, the black liquor being added via the flow 31 that has been withdrawn from the cooking stage via the withdrawal strainer 20. The level of residual alkali in the flow 31 normally lies in excess of 10 g/l, preferably 15-25 g/l.

Consumption of residual alkali takes place in the treatment vessel. Consumed black liquor, having a level of residual alkali below 10 g/l, is withdrawn from the strainer 16 for transport onwards to recovery 32.

The chips, following treatment with black liquor in the vessel 15, are fed to the digester 19 and it is appropriate that the alkali-rich fluid 30 is added to the chips before the cooking stage in association with the output 17 from the treatment vessel 15. The initial material that has been pre-treated in this manner is fed continuously to the top of the digester 19. Following cooking in, for example, a first concurrent flow and a final countercurrent flow, the cooked pulp is fed out from the bottom of the digester and onwards to washing equipment (not shown in the drawing), where the lignin that has been released during the cooking is washed out in order to obtain a cellulose pulp with a kappa value with respect to the conifer pulp with a value of approximately 30, preferably always under 40 and preferably between 35 and 25.

It will be realised that Figure 2 shows the principle schematically. It is to be understood, for example, that there may be several heating flows and several withdrawal positions both from the impregnation vessel 15 and from the digester 19. In

the same way, several other flows, additions of fluid and washing arrangements can be arranged at various locations. It must also be realised that the invention can be used, in principle, with all known conventional cooking processes.

During the actual cooking stage, which is here shown as two zones (concurrent flow and countercurrent flow), the temperature lies in the region 150±20°C. The normal retention time lies in the interval 40-240 minutes, and preferably approximately 120±20 minutes in each cooking zone.

Figure 3 shows a modified design according to the invention. The same type of cooking plant as that shown in Figure 1 is shown here, for the sake of simplicity. On the other hand, two separate raw material preparation units 1A, 1B are used. Thus, chips from an initial material comprising softwood are manufactured in the first wood preparation unit 1A, and solely softwood 2 in the form of logs is added to this unit. Solely hardwood logs 3 are added to the second unit 1B. Furthermore, it is indicated that raw materials storage spaces 1A′, 1B′, are located in direct association with the wood preparation units 1A, 1B for storage of each type of chips in separate spaces. A chip transporter 4 from the first unit 1A is available that feeds the chips towards the chip bin 10, while a second transporter 5 is available from the second unit 1B that feeds hardwood chips towards the same chip bin 10. It is ensured that the desired mixture of hardwood chips and softwood chips is achieved, either just before or in connection with input into the chip bin 10. This takes place through arranging a control unit 6 that ensures in a suitable manner that a controlled, desired mixing of the different sorts of chip takes place before input to the chip bin 10. It is appropriate that this takes place through the volume of flow out from each unit 1A, 1B being regulated by the control unit 6, such that a desired distribution of the percentages of each type of wood is obtained at the input to the chip bin 10.

Figure 4 shows a further modified method according to the invention. In contrast to the designs that have been previously described, sawdust 3A is used here as initial raw material for the addition of hardwood, instead of chips. The sawdust 3A is thus stored

in a separate container 7. The principle wood raw material in the form of softwood is added as in previous designs in the form of logs to a raw materials preparation unit 1 in which the chips, when ready, are transported by a transporter 4 to the chip bin 10. A control unit 6 receives information from this flow of chips and controls the addition of sawdust 3A to the digester 19 based on this input information, such that the desired amount of hardwood sawdust 3A is added to the digester 19. This addition can take place at a number of locations in the digester, for example, to a cooking flow 21 via a line 8 that is delivered at the cooking flow 21. Alternatively, or in addition, the sawdust 3A can be added by means of a line 9 at the top 18 of the digester 19, or it can be pumped to the input, the preimpregnation vessel, the transfer, or other suitable position.

It may be an advantage in certain applications to pre-treat the hardwood such that the xylan is released before the hardwood raw material is added to the softwood raw material. This can be achieved, for example, by pre-treating the hardwood at a temperature of 100-140°C in an alkali fluid (preferably in white liquor) before it is, for example, added to the impregnation stage and/or the cooking stage.

Figure 5 shows the tensile strength (along the y-axis) as a function of the degree of beating (along the x-axis), comparing a pulp from softwood (principally *Pinus sylvestris*), prepared according to the invention (upper curve) with 15% hardwood in the form of Scandinavian birch, with a softwood (*Pinus sylvestris*) pulp prepared according to a conventional method (lower curve), i.e. using solely softwood. The same cooking conditions and cooking process (CoC™, Compact Cooking, which has been developed by Kvaerner Pulping AB) have been used also in this experiment. The figure shows that the pulp produced according to the invention demonstrates a tensile strength that is improved by around 10%.
Figure 6 shows also the improved yield obtained from the process according to the invention, with 15% hardwood in softwood (*Pinus sylvestris*).
One effect of the mixing in of the hardwood is a certain decrease in the average fibre length from 2.49 mm to 2.11 mm, while fibre curl increases somewhat, from 11.8% to 12%.

Certain experiments have also been carried out with a larger fraction of spruce in the softwood. In these experiments, a softwood mixture with 70% spruce and 30% pine has been mixed with 15% hardwood. An increase in tensile strength of 5-10% was obtained.

If a batch cooking system is used for the production of cellulose pulp, continuous addition of hardwood sawdust cannot normally be achieved, and for this reason one of the principles according to Figure 2 or 3 should be used.

It is appropriate that the controlled addition of hardwood raw material takes place such that at least 1-20% of hardwood is present in the cooking stage at all times during the process. The control can thus be adjusted such that a controlled mixing takes place in the flow of raw materials such that the said fraction of hardwood is established for a pre-determined amount of wood raw materials. It is appropriate that this amount corresponds to preferably less than 50% of the amount that at each moment is present in a digester 15, and even more preferably less than 25% of the volume of the digester for wood raw material.

The control is to be adapted such that the desired amount of hardwood is present in a controlled manner during the cooking stage and such that this has sufficient time to release hemicellulose, and to distribute during the cooking stage the released hemicellulose essentially throughout the complete digester volume. It is normally desired that an even mixture of hardwood is obtained throughout the digester, although the hardwood in one extreme variant is concentrated to a number of locations in the digester. The variant shown in Figure 4 provides the possibility of obtaining a very even mixing throughout the digester, while at the same time using a waste product (sawdust) from the raw material preparation that otherwise would have been sent for incineration.

A targeted control of the supply of raw materials according to the invention thus allows a stable, high yield and improved tensile strength to be obtained for the cooked pulp.

The invention can be modified in a number of ways within the framework of the claims. For example, the invention can also be used in various types of combination according to the principles shown in Figures 2, 3 and 4; for example, in such a manner that a certain fraction of the hardwood raw material is added at the chip preparation while another part is added in the form of sawdust directly to a continuous digester. Furthermore, it will be realised that various forms of intermediate storage of wood chips and sawdust can take place, for example, with chips between the wood preparation unit 1 and the chip bin 10, or in close association with chip bin 10.